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ABSTRACT

The problems of those children who are chronically malnourished, the cultural environment of malnutrition, and the extent to which children are temporarily or permanently handicapped in learning because of malnutrition are discussed in this booklet. It also describes hunger and its effects on child development. The topics addressed are: definition of malnutrition, the prevalence of malnutrition, the brain, severe malnutrition and learning, chronic malnutrition and learning, deficiency and learning, hunger and learning, the cycle of malnutrition, and rehabilitation. It is concluded that prolonged severe malnutrition during gestation or early infancy when the brain is rapidly growing can lead to permanent behavioral handicaps. Such severe malnutrition is quite infrequent in the United States. The effects of moderate or chronic malnutrition are not as clearly understood. Adverse behavioral consequences of chronic undernutrition seem to lie in the areas of attentiveness, curiosity, activity, and social responsiveness rather than in learning itself. The consequences of iron deficiency are likely to be in these same areas. The incidence of hunger among children is nearly impossible to measure. Although it does not permanently affect the brain, hunger probably adversely affects learning. Corrective policies must include insuring preventive health care beginning with the pregnant mother and extending through childhood. (Author/AM)

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Malnutrition, Learning, and Behavior

April 1976

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As many as half of the world's children may suffer some degree of malnutrition. This booklet is offered by the National Institute of Child Health and Human Development (NICHD), of the National Institutes of Health, to focus the attention of health workers and teachers on the developmental problems of these children.

Critical aspects discussed include the cultural environment of malnutrition, the extent to which children are temporarily or permanently handicapped in learning because of malnutrition, and the effects of hunger on child development. Much of the recent research cited in this booklet was supported by NICHD.

This booklet was written by Merrill S. Read, NICHD, assisted by David Felson, Johns Hopkins University School of Medicine.

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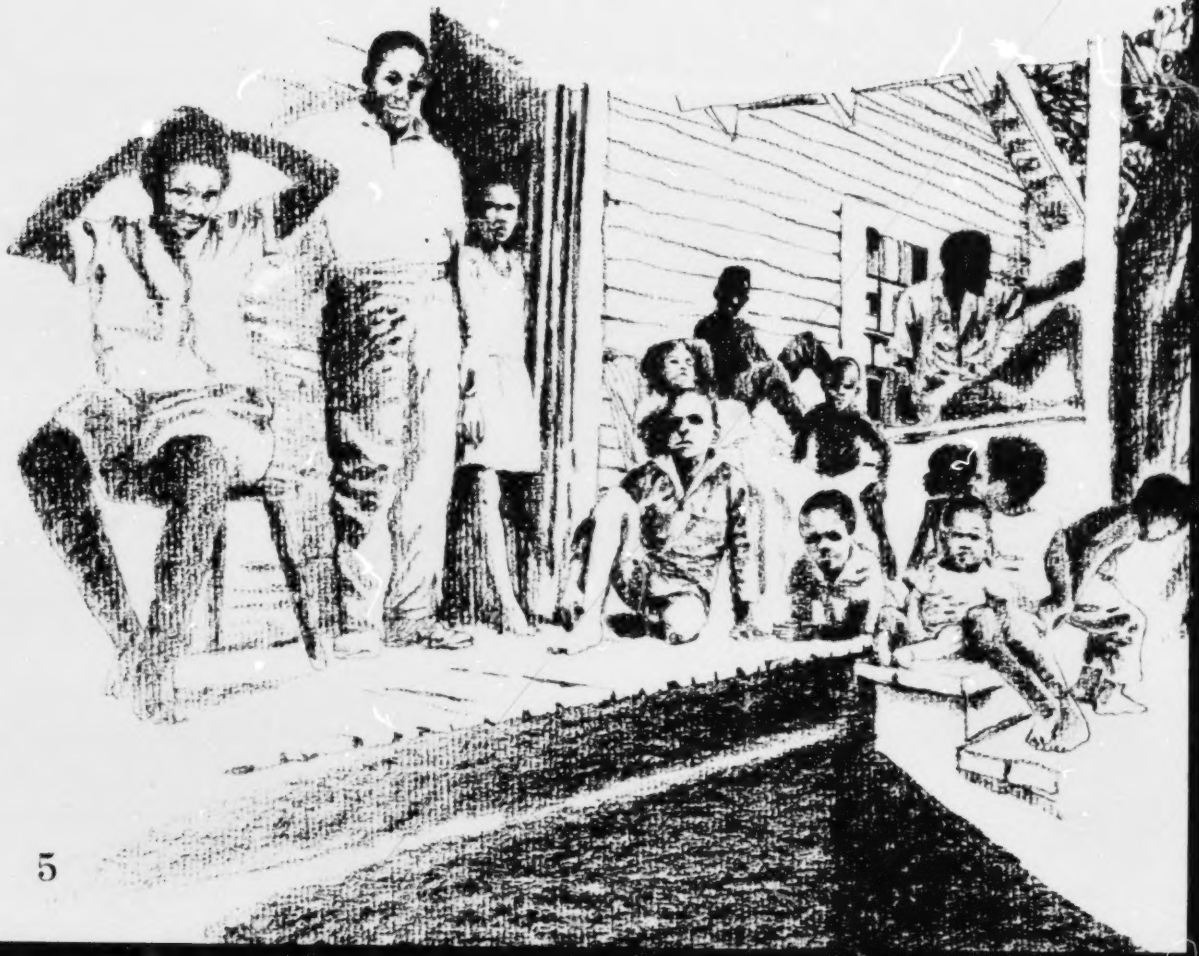


"You are what you eat" is a widely used expression whose scientific validity and public health implications increasingly are recognized by the world's nutritionists and medical doctors.

Children who do not get enough to eat and are malnourished tend to be smaller and to be sick more often. They also may be less able to learn.

To the extent that malnutrition occurs in the United States, children will not be able to achieve their full potential and realize a healthy and satisfying adult life. For developing nations worldwide, where children may constitute a large percent of the population, malnutrition may constrain the country's future social and economic development.

This booklet mainly focuses on the problems of those children who are chronically malnourished, the cultural environment of malnutrition, and the extent to which children are temporarily or permanently handicapped in learning because of malnutrition. This booklet also describes hunger and its effects on child development.

What is Malnutrition?

Malnutrition is a state in which a prolonged lack of one or more nutrients retards physical development or causes specific clinical conditions to appear, as for example, anemia, goiter and rickets.

Severe malnutrition generally is characterized by clinical manifestations often resulting in hospitalization. There are two basic types of severe malnutrition: *kwashiorkor*, in which there is protein deficiency; and *marasmus*, where there is an overall deficit of food, especially calories. Infantile marasmus is caused most frequently by early cessation of breast feeding, overdilution of bottle-fed formula, or gastrointestinal infection early in life. Marasmus is accompanied by wasting away of tissues and extreme growth retardation. Kwashiorkor generally occurs at or after weaning, when milk which is high in protein is replaced by a starchy staple food providing insufficient protein. A child with kwashiorkor is usually stunted in growth, has edema (accumulation of water), skin sores, and discoloration of dark hair to red or blond.

While only one to two percent of the world's children have severe malnutrition, up to half may suffer from moderate malnutrition or chronic undernutrition (the terms moderate malnutrition and chronic malnutrition are used interchangeably in this booklet.)

How are undernourished children identified? Biochemical and clinical signs of malnutrition are often used, but they are not very precise except in cases of extremely inadequate diets. Chronic or long-term undernutrition generally results in stunting of growth and the degree of malnutrition is often proportional to the degree that the child is subnormal in height or weight. Therefore, anthropometric measures (height, weight, and fatness) are the most commonly used indices of undernutrition.

There are two types of moderate malnutrition. One is caused by chronic food restriction (manifested by growth retardation), while

the other results from vitamin or mineral deficiency and is accompanied by clinical symptoms such as rickets or pellagra.

Malnutrition is most often associated with poverty. Determining its effects on a given individual is extremely difficult since many other factors influence human growth and behavioral development, including an individual's innate potential, his health status, and his environment.

The Prevalence of Malnutrition

In the world:

Malnutrition is mankind's most pervasive health problem. Probably more than half of the children in developing countries are moderately or severely undernourished. A recent United Nations report estimated that about 400 million people, one-ninth of the world's population, are starving or seriously malnourished.

Calorie deprivation, not necessarily protein lack, seems to be the world's primary problem. This shortage of food quantity is so serious in many populations that it masks vitamin and mineral deficiencies, whose prevalence in the world remains unknown.

In the United States:

Three extensive surveys of nutritional status in the United States have been conducted in recent years. They have reached similar conclusions: in the United States, marasmus and kwashiorkor are quite rare

(despite frequent assertions to the contrary), but chronic undernutrition and iron deficiency are surprisingly common.

These studies provided a wealth of information concerning food habits. For instance, almost twenty percent of the children under six consumed less than the recommended daily intake of calories. For low-income families this figure increased to thirty percent. Children from some Southern states and poor Black and Hispano-American children were much more likely to have insufficient calorie intakes.

Contrary to the expectations of many, adults and children generally had enough protein in their diets. The study of preschool children found that less than two percent did not eat sufficient protein. Protein consumption was closely tied to total calorie consumption. Thus, the children not eating enough protein tended to be those with low calorie intakes. In short, the problem appeared to involve the quantity rather than the nutritional quality of food.

Recommended daily allowances are only gross estimates of nutritional needs and, in fact, are not designed to assess an individual's nutritional status. A more accurate criterion of whether a child is receiving sufficient nutrients is the child's growth record.

The nationwide surveys consistently found a larger-than-expected percentage of children with very low height and weight for age, especially children from low socioeconomic classes. Many factors, including the mother's weight and nutritional status during pregnancy as well as the child's history of infection, contribute to the height and weight of a child. Nevertheless, the primary determinant is the adequacy of the child's diet. Consequently, the large number of children with

extremely low anthropometric indices suggests that chronic undernutrition is a significant problem in this country.

Many studies have shown that iron deficiency is widespread in the United States. Iron is present in only trace amounts in milk and in most baby foods. Furthermore, iron needs are greater after any infection or blood loss. More than one-half of the children one to five years old in the United States may have inadequate iron intakes, a deficiency which is not restricted to lower socioeconomic classes. Anemia, the medical consequence of prolonged iron deficit, is common in this age group also, climbing to thirty percent prevalence in some low-income groups. Iron deficiency seems to recede in incidence at about age five and reappear as a major nutritional problem in adolescence for both boys and girls.

Finally, except for iron, the national surveys found little dietary or clinical evidence of vitamin or mineral deficiencies among the children in this country, once again belying a commonly-held opinion.

Malnutrition and infection:

Malnutrition impairs the body's defenses against disease. Consequently, infection, omnipresent in underdeveloped regions of the world due to poor sanitary conditions, occurs more frequently in malnourished children. Just as malnutrition increases susceptibility to disease, certain types of infection, especially gastrointestinal ones (including the widespread diarrheal disease of infancy), heighten vulnerability and aggravate the severity of malnutrition.

To the extent that the poor in the United States live under unsatisfactory health conditions and are without access to medical care, malnutrition and infection interact here also.

The ecology of malnutrition:

Malnourished children are most frequently from families that are poor, have many children closely spaced in age, and do not participate fully in public health programs. They are more likely to come from one-parent households. Parents of malnourished children generally have low-status, unskilled jobs reflecting their lack of education. In short, malnutrition is usually found where there is poverty, and many aspects of this environment, including malnutrition, affect learning.

The Brain, A Special Vulnerability in Infancy?

The human brain approaches its adult size, weight, and cell number by age two. From about the second trimester of pregnancy to six months of age, there is a "brain growth spurt" when brain cells rapidly multiply and grow. To a lesser extent this period of rapid brain growth continues until 18 to 24 months of age.

The brain growth spurt may be described as occurring in two general stages. The first stage, concurrent in man with the second

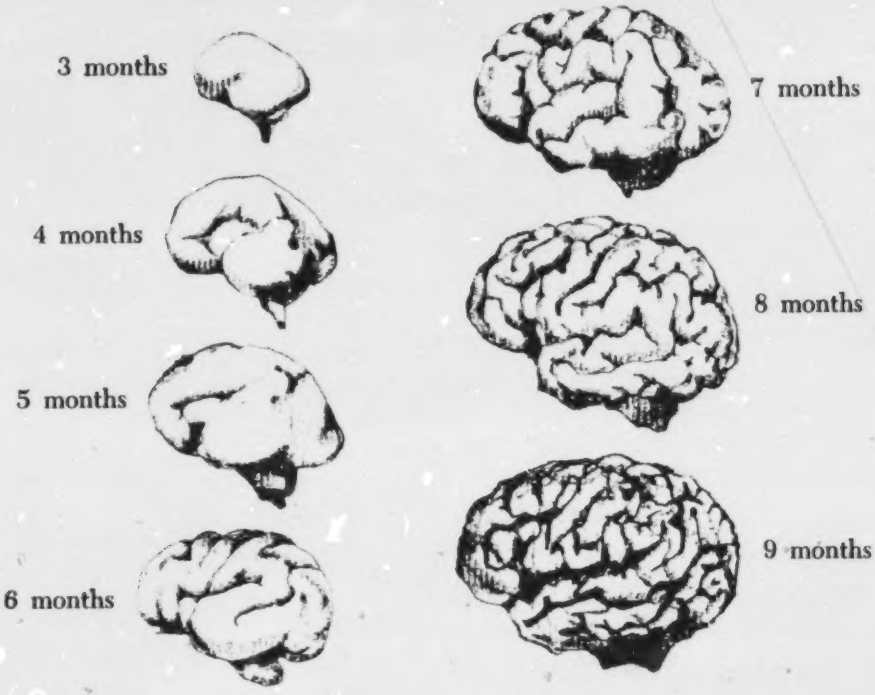
trimester of pregnancy, involves increasing the number of neurons, the basic functional cell of the brain. The second stage extends from the third trimester of pregnancy through the normal period of breast feeding. Throughout this stage the supporting cells of the nervous system (the glia) multiply and branches (dendrites) from already established neurons grow to form synaptic connections which transmit impulses between neurons.

The two stages overlap considerably, and many neurons are still multiplying even after birth. Of immediate interest is that the processes of dendritic growth and formation of synapses which occur mainly during the second stage are probably more important to human mental performance than is neuronal cell number.

Superimposed on the two stages of the growth spurt are regional variations in brain development. Some sections of the brain develop earlier than others, and some develop quickly while others evolve more slowly.

Throughout its growth spurt, the brain needs adequate nutrients in order to grow. Research findings in animals now indicate that severe malnutrition during this period can produce brain deficits which cannot be rectified nutritionally.

In rats severe nutritional deprivation during the first phase of the growth spurt leads to a permanent reduction in neuronal cell number. Extremely restricted food intake in the course of the second stage, prior to weaning, creates a brain reduced in diameter (because



The human brain increases in size and complexity of cortical folding from 3 months of gestation to birth.

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of stunting of cell growth) and diminished in cell number. A combination of prenatal and early postnatal malnutrition has a cumulatively greater effect than either alone. In lower animals the brain growth spurt is a critical period during which malnutrition leads to permanent behavioral changes.

The unique human brain, however, may not be so vulnerable throughout the growth spurt because: (1) it is so complex and comparatively large that many cells or branches perform similar functions, suggesting that loss of a few cells may not portend behavioral deficit; (2) it may be preferentially allocated scarce nutrients, thereby sparing the brain from developmental deficiencies; and (3) the first stage of the human growth spurt occurs during the second trimester of pregnancy, when the developing brain is relatively protected by the nutrient stores and body processes of the mother.

Nevertheless, the available evidence shows that the human brain, like those of other animals, is probably more vulnerable to malnutrition throughout the growth spurt than at other times. The fetal brain is most likely to be affected in women whose body stores of nutrients are reduced due to a lifetime of undernutrition and an inadequate diet during pregnancy. The region of the brain that needs nutrients most is that which is growing most rapidly at that time, and is the region most affected when the nutrients are missing. Since each region is involved in certain brain and behavioral functions, a deficit in one region caused by malnutrition might produce specific behavioral abnormalities.

Severe Malnutrition and Learning

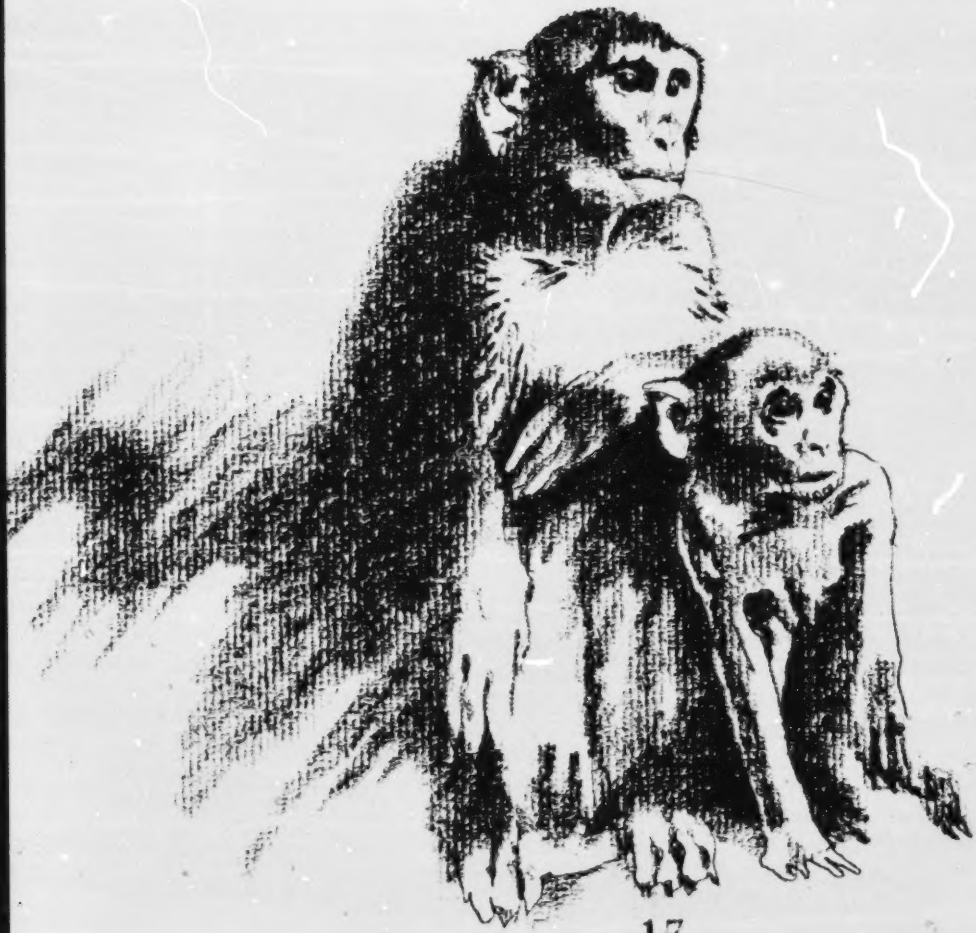
Many studies have been done with humans and animals to determine if severe malnutrition (prolonged calorie or protein deprivation leading to gross clinical symptoms and frequently to hospitalization) results in permanent learning handicaps. A number of important conclusions have been drawn.

Animal studies:

Experiments with animals are extremely useful in elucidating the impact of malnutrition. Environmental variables which contribute to malnutrition's effect on learning can be held constant. Investigators can use animals with short life spans instead of having to wait years to evaluate the long-term consequences of malnutrition, as is necessary in man.

Studies using animals, especially rats, have shown almost without exception that severe malnutrition in infancy or prenatally does lead to permanent behavioral abnormalities. These effects include apathy and reduced exploratory behavior and problem-solving ability.

The most consistently observed consequence of malnutrition involves animals' arousal levels. Malnourished animals, even after rehabilitation, are more irritable and more nervous. Altered arousal behavior and attention in previously malnourished rats may contribute to their frequently, although not universally, observed poor learning performances.



Several studies have shown that malnourished animals interact less well with their mother and peers. For example, monkeys raised on an inadequate diet were described as withdrawn and socially maladjusted.

Severe malnutrition in humans:

Animal studies provide significant leads to human behavior. However, research findings from animals cannot be directly extrapolated for two reasons. First, the rat brain growth spurt takes place almost exclusively after birth when the rat is quite vulnerable to nutritional insult, whereas human brains undergo much of their development in the comparative security of the womb. Furthermore, nutritional deprivation corresponding to forty percent reduction in weight gain is necessary before permanent neurological deficits can be induced in the rat. Comparable curtailment of growth in man is rarely seen except in cases of severe malnutrition such as marasmus or kwashiorkor or in those low birth weight babies who do not grow adequately after birth.

In spite of these qualifications, severe malnutrition in infancy apparently does significantly alter human behavior. The impact on human behavior is directly related to the severity of malnutrition and its duration during the brain growth spurt period. One investigator has suggested that any malnutrition severe enough to require hospitalization due to growth failure before two years of age will have irreversible adverse results. Another has postulated similar effects from any bout of extreme malnutrition lasting longer than four months during early life.

Specific behavioral effects of malnutrition: Early research on malnutrition and behavior tended to use general indices of intelligence, such as the intelligence quotient (I.Q), when measuring behavior after infancy. In most of these studies, environmental variables were not taken into account in comparing previously malnourished children to others. Not surprisingly, therefore, these studies asserted that malnutrition had a potent effect on all aspects of intelligence.

More recently, research in the field has become more accurate and discerning. Environmental variables that contribute to behavior and intelligence have been more correctly measured and accounted for, so that malnutrition's effects alone could be better approximated. Also, intelligence measures have been refined so that behavioral alterations could be delineated. What has emerged, as animal studies suggested, is a picture of severe malnutrition exerting specific effects on later behavior.

First, there is a permanent effect on motivation, attention span, and arousal. Children who were severely malnourished early in life seem to have short attention spans and consistently perform poorly on tests of concentration ability. On the other hand, long-term memory does not appear to be impaired by malnutrition.

Also, severely malnourished babies tend to develop into children with motor insufficiencies. Many show abnormal difficulties manipulating objects, owing to a lack of fine motor control.

Finally, children malnourished during infancy probably have some as yet undefined retardation in sensory integration. For example, such a child learning to read may have difficulties connecting the visual image of a word with the sound of a word. Obviously, learning would

be considerably retarded by impaired sensory integration, but the types of integration that may be affected are not yet fully delineated.

As might be expected, these previously deprived children seem to do poorly in school. They tend to be marked as problem children by their teachers and usually get lower grades.

In sum, very severe malnutrition in infancy, if of long duration and followed by childhood undernutrition, produces irreversible effects on behavior which, in turn, impair a child's ability to learn.

Chronic Undernutrition and Learning

Moderate or chronic undernutrition is more prevalent in the world than severe malnutrition, and occurs even in the United States, as evidenced by poor physical growth and anemia. In spite of this, there are fewer reported studies on undernutrition, and the findings are more confusing. First, the effects, if any, are probably less serious and therefore harder to measure. Second and equally important, moderate or chronic malnutrition must be viewed in the context of the malnourished child's social and familial environment, many parts of which also shape behavioral development. Thus, studies have been difficult to design and execute and even harder to interpret.

Despite these problems, a number of studies in Mexico, India, Africa, and the Caribbean have shown that chronically undernourished children tend to lag behind their well-nourished counterparts in be-

havioral development. This retardation probably lasts at least until adolescence. The primary deficits appear to involve motor-integrative performance, reading ability, concentration, and motivation. Even within the same family, those children who were more poorly nourished did less well on behavioral tests and in school than did their better nourished brothers and sisters.

Nevertheless, not all of the behavioral effects can be attributed to malnutrition. Socioeconomic factors contribute importantly to performance as seen when physically comparable children from different social strata were compared.

The best way to determine an individual's nutritional status is to measure what he eats over time, and recent studies have undertaken this longitudinal approach. Generally, one group of participants is nutritionally supplemented while another group from the same environment is not. All participants in these projects receive previously unavailable comprehensive medical care.

The largest and most thorough of these studies is presently being conducted in rural Guatemala. The infants, both supplemented and unsupplemented, are being followed throughout childhood, tested and measured frequently on nutritional, physical growth, and intellectual parameters. Socioeconomic variables and family interactions are being recorded as well.

Nutritional supplementation has increased birth weight, which tends to be low in these populations. The supplemented children have grown better. By the age of three years, there are significant differences

in behavioral test scores between the supplemented and unsupplemented children. The improvements involve motor and manipulative skills rather than cognitive ability per se.

Other intervention studies have shown that nutritional supplementation starting in pregnancy and continuing into early childhood creates more physically active children who demand much more of their parents' time and attention. Conversely, undernourished children are less active and do not participate fully in the surrounding environment. The behavioral development of these latter children is below normal.

Iron Deficiency and Learning

Iron deficiency, the most prevalent nutritional problem in the United States, is defined as the depletion of iron stores in the body. It can be measured in various ways. Usually a significant and prolonged deficit in iron intake will cause anemia which is defined as the condition in which either the hemoglobin concentration or the volume of packed red blood cells (hematocrit) is lower than normal. Many people are iron deficient without manifesting iron-deficiency anemia. Since anemia constitutes the most frequent evidence of iron deficit, most of the published studies have used this as the primary variable.

Like other forms of malnutrition, the more severe the anemia, the greater its effect on behavior. Only very severe anemia appears to have

any measurable impact on adult performance. Mild anemia, on the other hand, significantly influences behavior in young children. This is probably due to the combined impact of anemia and rapid growth. However, no data as yet suggest that permanent neurological damage results from anemia either during pregnancy or early childhood.

Childhood anemia does not seem to have any direct effects on intelligence, as measured by I.Q. tests. Rather, selected behaviors appear to be affected. Attentiveness and persistence are decreased in anemic children, while irritability is increased. Chronic undernutrition in conjúnction with anemia probably has a more deleterious effect on behavior than anemia alone.

Unlike severe malnutrition, a history of anemia, either in gestation or early infancy, does not impair current performance. The presence of iron deficit at the time of testing is the significant variable.

The impact of iron deficiency on behavior probably is not related to the anemia which so often accompanies it. Iron supplementation will quickly relieve adverse behavioral consequences. The physiological basis behind the effects of iron depletion are, at this point, unknown, although some have speculated that enzymes which require iron for activity are sensitive to iron levels in the body.

Whatever the physiological explanation, if a child withdraws from his environment as a result of iron deficiency, he fails to learn. By missing one step in the learning process, he is less equipped to learn the next. Prolonged iron deficiency, like chronic undernutrition, could irreparably impair intellectual development, even if neurological structures remained essentially intact.

Hunger and Learning

Up to one-fourth of American school children arrive at school without eating breakfast; many others do not have lunch. Often such children are hungry.

Hunger and malnutrition are not identical. Whereas malnutrition consists of specific physiological symptoms caused by prolonged lack of food, hunger is a physiological and psychological state resulting when immediate food needs are not met. Hunger can be relieved quickly by food, but recovery from malnutrition requires extended rehabilitation.

Hunger is nearly impossible to quantify. Consequently, despite the numerous studies based on school breakfast, snack, or lunch programs (food intervention to relieve hunger), many of the questions about hunger's effects on behavior and growth remain unanswered. The varying results of school food programs in terms of improved growth and nutritional status undoubtedly reflect the varying degree of undernutrition among the children in the programs. Attempts to measure behavioral changes resulting from school feeding programs have been poorly controlled, and many children in the studies were both undernourished *and* hungry, futher obscuring research results.

Nevertheless, the consensus of the studies is that hunger affects behavior. It increases a child's nervousness, irritability, and disinterest in a learning situation. Thus, although hunger probably has neither direct effects on learning, nor permanent effects on behavior, it potentially disrupts the learning process. A hungry child's disinterest and

inability to concentrate tend to isolate him, and when others respond negatively to his behavior, his isolation is heightened, creating a vicious circle. The child fails to learn for social and psychological rather than biological reasons.

The Cycle of Malnutrition

As is apparent from the previous sections, malnutrition and environment are intimately intertwined. This interaction often creates a cycle wherein poor environment leads to malnutrition, which in turn shapes behavior to perpetuate poverty, intellectual disability, and malnutrition.

Women who have been undernourished throughout life differ from well-nourished mothers in at least three significant ways. First, they tend to give birth to babies who are undernourished and underweight. Secondly, if they are undernourished during pregnancy, the quantity of their breast milk and the duration of breast-feeding are reduced, even though the quality of the milk is probably unaffected. Finally, the undernourished mother plays less with her new child since she is considerably less active than normal mothers.

From birth until weaning the infant receives most of his nourishment and environmental stimulation from his mother. The breast-fed child is probably fairly well-fed throughout early life because of his low nutritional needs. But, by six months of age (or even earlier if the mother is very malnourished) the amount of maternal milk begins to limit growth.

As the infant's needs begin to surpass the undernourished mother's ability to fulfill them, the infant tends to become less active, conserving his food energy. The energy needs for physical growth take precedence over energy for activity and play.

Not surprisingly, at about six months of age, the undernourished infant becomes visibly distinguishable from normal infants. According to a longitudinal study done in rural Mexico, this infant sleeps more and plays and explores his environment considerably less. The less active malnourished young child elicits less stimulation and attention from parents, siblings, and later from his peers. The mother leaves him in the cradle for longer periods of time. The net effect is that the malnourished infant tends to develop into a passive, apathetic child.

Furthermore, an infant undernourished before weaning is apt to become more malnourished. This is due to his lack of activity and demands on the mother. In addition, his sucking behavior may be both less effective and less frequent. Thus, this baby probably receives less milk because he is already undernourished.

At weaning the infant more fully enters the outside world. During the post-weaning period, the malnourished child's developmental deficits may be multiplied. The normally active infant plays more and more with his parents and brothers and sisters at this stage. Well-nourished children are spoken to more frequently, praised and rewarded more often. The undernourished infant, on the other hand, does not advance in developmental level, probably because he is timid, passive, explores

little, and demands little. This child has become accustomed to meager food supplies and has assumed a conservative mode of living consistent with available energy. He cannot develop satisfactorily because development requires physical activity which he cannot, over the long run, afford.

Thus, a picture has emerged of a chronically undernourished child developmentally disadvantaged in many ways. What happens when this child interacts with peers and goes to school?

By the time a child enters school, he has developed a self-concept based on how parents and others respond to him. Up until this time, the malnourished child has probably had great difficulty concentrating and was spoken to and praised infrequently. He most likely thinks of himself as less able, a picture which will be confirmed when he tries to concentrate on learning tasks in school. Activity is harder for him, and attention is often interrupted by concern for food. What results is a lost, discouraged child whose future prospects in school are gloomy at best.

Early malnutrition then has come full circle, helping to create a child with learning difficulties. It is important to understand that a continuum exists extending from one end where prolonged severe malnutrition causes an infant to be very passive throughout early life to the other end where a transitory epidsode of hunger may induce an infant to be less active for a while. Obviously, the longer and more profound the passivity, the greater the effect on overall intellectual development.

Is Rehabilitation Possible?

How much can children who were severely malnourished in infancy be rehabilitated behaviorally? Two recent reports have shed light on this question.

One intriguing study involved babies with cystic fibrosis, a disease which leads to a failure of intestinal absorption. These babies were well fed by their middle class families, but they failed to grow due to malabsorption. They were therefore judged to be severely malnourished. After treatment they grew normally. Follow-up tests on them showed behavioral retardation through the first five years of life. After that the retardation gradually disappeared presumably because the children were raised in a favorable social environment.

In another study Korean children known to have had severe malnutrition early in life were adopted by families in the United States. By age seven, the children were normal in intellectual performance by American standards. Other Korean children who had never been malnourished and were also adopted by American families were similarly tested. They were above normal in intelligence. These observations suggest that the malnourished children, even though they were not retarded in later life, were never able to achieve their full intellectual potential.

What about rehabilitating the chronically undernourished child? A study of preschool children in urban Colombia revealed that nutri-

tional supplementation alone starting at age three had almost no effect on psychological test scores. When educational stimulation and additional food were combined, however, both malnourished and normal children from poverty areas improved their performances markedly on various behavioral indices. Even so, the poor children remained below upper class children in intellectual performance, emphasizing again the importance of the environment.

Also, an investigation of Mexican children showed that up to age seven, intellectual test scores corresponded above all to previous nutriture (determined by physical growth). By age 11 to 12, however performance was more a function of socioeconomic status and regularity of school attendance than it was of nutritional history.

These studies suggest that physical rehabilitation from malnutrition is not enough. Improved health care, nutritional supplementation, and enrichment of the child's social and cognitive environment must be combined. Comprehensive interventions will help most malnourished children, except the most severely malnourished, to achieve close to normal intellectual performance for their cultures.

How much more could these children learn and achieve, however, if they had never been malnourished? Are malnourished children prevented from reaching their innate intellectual potential even though they may reach normal levels, as was suggested by the studies on adopted Korean children? A comprehensive answer to this question lies in the realm of future research.

Conclusion

Prolonged severe malnutrition during gestation or early infancy when the brain is rapidly growing can lead to permanent behavioral handicaps. Such severe malnutrition is quite infrequent in the United States.

The effects of moderate or chronic malnutrition are not as clearly understood. Man lives in a complex environment where nutrition, health, family, and social factors interact to shape behavioral development. Adverse behavioral consequences of chronic undernutrition seem to lie in the areas of attentiveness, curiosity, activity, and social responsiveness rather than in learning itself.

Furthermore, the consequences of iron deficiency, the most common United States nutritional problem, are likely to be in these same areas. Iron deficiency probably has no permanent effects on brain structure and function. Even so, the temporary changes in behavior it induces interfere with learning.

The incidence of hunger among children is nearly impossible to measure. A hungry child is listless, nervous, and disruptive. Consequently, even though it does not permanently affect the brain, hunger probably adversely affects learning.

Although all the research has not yet been completed on malnutrition and learning, corrective policies should be started now. These must include insuring preventive health care beginning with the preg-

nant mother and extending through childhood, assuring nutritionally adequate food supplies over the same period, and providing suitable social stimulation and education for children. It must also be recognized that nutrition, health, and family planning programs are necessarily closely interrelated. Family and community resources must be mobilized, and targeted national health policies are needed.

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